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A SYSTEMS ENGINEERING PROCESS SUPPORTING THE DEVELOPMENT OF OPERATIONAL REQUIREMENTS DRIVEN FEDERATIONS

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ABSTRACT

This paper proposes a systems engineering process utilizing the conceptual artifacts of the Model Driven Architecture (MDA) describing platform independent views of models to capture operational requirements, to derive essential tasks, and to combine these tasks into scenarios and vignettes with attributed metrics. This model-independent mission description is then used to identify supporting simulation services that implement the identified military means and capabilities to perform the tasks in the given context. Once the services are identified, the necessary simulation middleware to federate the services is identified and the interfaces are configured using the technical artifacts of the MDA describing platform specific views of systems. This systems engineering process provided support for simulation development for the US Army's Program Executive Office – Soldier.

1 INTRODUCTION

Old Dominion University (ODU) and the Virginia Modeling Analysis and Simulation Center (VMASC) support the US Army with expertise on systems engineering processes, in particular on the use of principles of the Model Driven Architecture (MDA) supporting simulation system interoperability. In a recent project conducted in collaboration with the United States Military Academy, a systems engineering process was developed that utilizes the artifacts of MDA to support building federations driven by operational requirements. This paper documents the process, gives an example, and summarizes some necessary requirements to apply this process to align acquisition, development, testing, training, and operational support for the armed forces.

The systems engineering process proposed in this paper is based on several relevant and community accepted methods and standards. In the second section of this paper, these methods are reviewed in order to root the proposed process in already accepted work. At the same time, alternative views, that are currently often perceived to be competing alternatives, are supported by a common process. Due to the enormous variety of supporting methods and standards, the section can be neither complete nor exclusive. The documented principles should support extending this to other alternatives as well, and the authors welcome related discussions.

The third section shows how the artifacts of MDA can be used to unify the different contributions as a technical support of the recommended systems engineering process. The components of Computer Independent Models (CIM) and Platform Independent Models (PIM) are used to model mission essential task and compose those into vignettes and scenarios. The resulting elements describe a task that needs to be performed in a given operational context. In addition, metrics are assigned that measures how well a system with the required capability fulfills this task in the given context. Next, the selection of simulation services is conducted based on these vignettes. In order to be able to support this, the simulation service capabilities themselves must be specified as PIM as well.

Once the project manager – or his supporting technical advisors – decides which system will support the evaluation with which capability, the work can be transformed to the technical level. The selected simulation services need to be federated on available simulation middleware solutions. These can be standardized solutions, such as the Runtime Infrastructure (RTI) of the High Level Architecture (HLA) or the use of Protocol Data Units (PDU) as defined in the Distributed Interactive Simulation (DIS) standards, or industry standards, such as Web services. In addition, the mapping to very efficient special solutions, such as binary links in radio-based communications, is possible as well, although this seems to be the exception. Once the technical protocols are selected, the Platform Specific Model (PSM) artifacts of MDA can be applied to generate the necessary interfaces, mapping, and connections. Additional support can be provided when Base Object Models (BOM) are used.

The ideas were used in support of an acquisition task currently conducted by the US Army. The Army's Program

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Executive Office (PEO) - Soldier has the complex task of acquiring and integrating a system of soldier equipment that meets their mission requirements. In order to better assess trade-offs in different soldier architectures, they seek an improved simulation capability that better represents the individual soldier on the battlefield. No single model provides this capability. They are pursuing a strategy of integrating three different simulation models to take advantage of the strengths of each. In section four, we show how the definition of questions in support of acquisition decisions is supported by the systems engineering process using the MDA artifacts. The examples given here are only a small subset, but the principle can be shown.

In section five, the idea is generalized beyond the example. Currently, acquisition, development, testing, training, and operational support are only loosely coupled. The approach recommended in this paper allows the reuse of significant findings, operational requirements, and constraints bridging the phases of the life cycle of a system. This results potentially in better aligned support for the warfighters needs. The supported project shows the feasibility of these recommendations.

2 RELEVANT METHODS AND STANDARDS

The necessity of applying systems engineering processes in support of system decisions in all phases of the life cycle is nothing new. Also, to anchor such processes in the operational necessities defined by requirements is common procedure. What is innovative is the idea to use common artifacts in support of all phases of the useful life cycle of systems in a consistent way, covering all aspects of the operational life cycle. This starts with the identification of an operational gap, a certain capability that is required to implement doctrine. Once this capability is identified, the procurement and acquisition community has to decide if a new system should be introduced to deliver the function implementing the capability, or if an existing system can be improved to provide the functionality.

On the operational side, these steps can be supported by the Military Missions and Means Framework (MMF) and related task list activities. This will be described in the first subsection. This process is closely related to the task to produce operational views in the DoD Architecture Framework. The systems view is represented by the systems and capabilities that are used to provide the means within a mission.

The technical guidance is provided by guidance documents and standards. In the second subsection, the Federation Development and Execution Process (FEDEP) supporting HLA and the more general counterpart often applied in Europe, the Synthetic Environment Development and Exploitation Process (SEDEP) will be used to show necessary steps that need to be supported by the systems engineering process. In addition, the NATO Code of Best Practice (NCOBP) for Command and Control (C2) Assessment gives guidance as well.

Finally, MDA and the necessary PIMs and PSMs ideas are described in the third subsection. Although not used in the study, the use of BOMs has been identified as additional support. Scope and resolution of this overview are limited to the level needed to understand their application in the following section, in which the resulting recommended systems engineering process will be described.

2.1 Missions and Required Capabilities

Truly integrated operations depend on a solid foundation of common elements understood between all participating partners and organizations. The current approach is to establish a mission essential task list (METL) that lists the operational tasks forces need to perform to doctrinally accomplish a given mission. These tasks may also be mapped to a common Universal Joint Task List (UJTL). Several separate initiated US DoD programs as well as some Homeland Security efforts are planning to base their metrics of performance on mission essential tasks (MET). Within NATO, comparable efforts are undertaken, although the resulting task lists are not always well aligned between all nations. Despite the need for better harmonization, in all these efforts a military task is identified and necessary capabilities to perform these tasks are captured. The targeted result is a list of mission essential tasks, related capabilities, and metrics to measure the performance. It should be pointed out that an MET should not be tightly coupled with a system or a capability implementation. The MET should describe the conceptual capability which – at least in theory – can be delivered by several systems or system components.

These ideas are tightly connected with the MMF: the context is defined by a military mission – which is a set of MET – and military means that are needed to conduct the mission. The MMF is therefore the operational view describing what operational nodes are needed and which operational activities are conducted. The systems, which are normally systems that have to be evaluated or that are under test, provide capabilities that implement the means needed to conduct a mission. This is consistent with the systems view: how are missions and means concretely instantiated? In order to assure scientific evaluations based on experimentations, a metric is needed that captures

(a) what data is collected, and

(b) how this data is used to define success or failure.

In order to be able to conduct the evaluation, these task elements must be put into a meaningful operational context. This is done by setting them into the context of a scenario or a vignette.

The focus of all these activities should be the evaluation of the system to be evaluated or under test. It is essential to track other capabilities and their relative changes based on the system to be evaluated as well, in particular when it comes to indirect or higher order effects, but the system is the main part of this effort. Therefore, the design process for setting up a scenario is as follows:

1. All tasks that are conducted by the system are added to the task list to be evaluated
2. All tasks that are supported by tasks conducted by the system are added to the task list
3. All tasks that are influenced (higher order effects) by the system are added to the task list
4. Operational vignettes or scenarios comprising all tasks on the task list (if necessary prioritized by operational effects) are defined

The result of these steps is a scenario or a list of vignettes that comprises all tasks and metrics needed to evaluate the system.

2.2 FEDEP, SEDEP, and the NATO Code of Best Practice for C2 Assessment

In order to support the evaluation, it is more than likely that more than one simulation system will be used. The selection of contributing systems should be based on the simulated systems, their capabilities, and their ability to support the desired metrics. The NATO Code of Best Practice for C2 Assessment was produced in order to facilitate high quality assessments. It identifies several steps of an iterative process:

- In the initial phase, the team starts with the *problem formulation* and related high-level *solution strategies*. This corresponds with the question of what the system to be evaluated should do in support of which missions.
- In the second phase, three steps have to be conducted to refine the ideas of the initial phase. In this phase, the team identifies the *Human and Organizational Factors* (the concepts to be evaluated, where they are, how they operate, etc.) and put them into the context of a *Scenario*. In addition, the *Measures of Merit* are decided. This phase deals with identifying the important concepts and processes, their role in a scenario, and how to measure success or failure.
- Only after the conceptualization is done, the implementation phase is conducted. The selection of *Methods and Tools* – such as simulation systems to use, but also supporting tools for the evaluation – is one of the steps. As important as the tool selection is to ensure that the necessary *Data* is available or can be obtained within the constraints of the project.
- Finally, *Risk and Uncertainty Management*, including sensitivity analysis of proposed solution, is conducted before the project is summarized in the deliverables.

The NCOBP is an operations research process. It recommends best practices on the structure of a project. In order to give technical guidance, other sources are needed. For federation development, the IEEE 1516.3 guideline on the Federation Development and Execution Process (FEDEP) or the Euclid RTP 11.33 description of the Synthetic Environment Development and Exploitation Process (SEDEP) is needed. Both processes are similar, as the FEDEP was used as a guideline when the SEDEP was developed. Although the focus is more technical than in the NCOBP, the necessity to build a strong conceptual model before going into the technical details is emphasized in both approaches.

- The SEDEP starts with an explicit *User Needs Analyses* that is not supported by the FEDEP. The following steps are well aligned, as the SEDEP understands itself as an enhanced FEDEP. One of the enhancements is the support of a common repository for all produced artifacts.
- The development process starts with refinements of the user requirements that lead to operationally driven federation system requirements for the SEDEP. On the FEDEP side, defining the federation objectives and developing a conceptual model for the federation are the counterparts.
- Based on this operational understanding, the federation is designed, implemented, integrated, and tested in both process models. In both models, the selection of federates is based on the operational requirements.
- Finally, the federation is operated, which means that the federation is executed and respective results are prepared. The SEDEP explicitly ends the process with performing an evaluation, which is kind of integrated into the execution phase of the FEDEP.

Both process models clearly show the primary importance of operational requirements. Both make technical recommendations, but the implementation details are left to the model developers.

2.3 The Model-Driven Architecture

The Model Driven Architecture (MDA) was developed under the lead of the Object Model Group (OMG) to facilitate reacting to business and technology changes. The underlying idea is to separate business and application logic from underlying technology. To enable this, MDA defines artifacts based on the Unified Modeling Language (UML) to describe a hierarchy of models that cope with the various challenges on different levels.

- The highest level of abstraction is the *Computation Independent Models* (CIM). This is a conceptual model that identifies the concepts and processes important on the business level. This is

easily mapable to the missions and means identified on the operational level. The main artifacts are use cases.
- The *Platform Independent Models* (PIM) capture concepts and processes in software engineering artifacts of class and object hierarchies, activities, sequences, and other means showing the roles of each component. PIM are very close to conceptual models that already use vignette and scenario elements motivating the various possible actions and their sequencing.
- If this conceptual model is mapped to a concrete platform and implementing language, middleware to be used, etc., the result is a *Platform Specific Model* (PSM). In the optimal case, the PSM can be used to produce code, as all information needed is available.

It should be pointed out that the models in the different layers are not developed independently from each other. Every use case of the CIM must be represented in form of sequenced actions engaging the roles as concepts in the PIM. The conceptual ideas of the PIM must be mapped to implementing entities, their capabilities and associations, and supporting interfaces on the PSM level. In theory, this is supported by the use of defining patterns. If the supporting middleware has an equivalent alternative, this approach allows switching between representing PSM without having to change the PIM. In other words: A federation can be implemented using both middleware approaches alternatively.

In the M&S business world, some M&S middleware and integration providers are utilizing this idea to support the migration between equivalent – or at least sufficiently close – implementations, such as supporting the Runtime Infrastructure interfaces defined in IEEE1516 as well as the alternative defined in version 1.3 NG (DoD).

2.4 Base Object Models

Base Object Models (BOMs) are a recently accepted M&S standard (SISO 2006). BOMs provide a key mechanism in facilitating interoperability, reuse, and composability. The BOM concept is based on the assumption that piece-parts of simulations and federations can be extracted and reused as modeling building-blocks or components. The interplay within a simulation or federation can be captured and characterized in the form of reusable patterns. These patterns of simulation interplay are sequences of events between simulation elements. What is of particular interest in this paper is that the artifacts used to describe the behavior, activities, and interplay between components – including the resulting state changes in the sending and receiving system for each interaction – are UML artifacts describing the "state machine" and the "pattern of interplay."

Although BOMs was developed in support of the High Level Architecture, their application is not limited to HLA federations. The metadata produced to describe the entities, behaviors, state changes, and interplays are generally usable conceptual constructs. In the scope of the presented study, this means that simulation components and simulation systems that are described following the BOM standard already provide a significant part of the information required to support machine-supported selection based on operational requirements, as the BOM description can be interpreted as a "Core PIM" for the component. Gustavson and Chase (2007) summarize related ideas.

In this section, we identified that the MMF and METL support the operational analysis of what the relevant tasks are when a system needs to be evaluated. The result is a description of tasks in the context of vignettes or scenarios with applicable metrics. Operational requirements should also drive technical selection and integration. The NCOBP as well as the modeling and simulation standards FEDEP and SEDEP show which steps are needed to set up and execute a federation. Separating business logic and platform specification leading to a hierarchy of models allows the MDA to facilitate the migration between equivalent or closely related technical solutions. BOM is a potential standard supporting the identification and selection of applicable components.

In the next section, we will document a systems engineering process that integrates these ideas enabling the seamless management of federation development for system evaluation from the operational analysis to the technical details of middleware selection and interface design.

3 THE SYSTEMS ENGINEERING PROCESS

The systems engineering process proposed in this paper was developed collaboratively by Old Dominion University and the US Military Academy. It was motivated by the need to support the project management with a consistent view of PEO Soldier challenges in compliance with relevant processes as described in the last section:

- The essential tasks to be used for the evaluation should be identified to support the selection or development of relevant vignettes or scenarios.
- Simulation systems should be selected based on their ability to support the evaluation of these tasks. The simulated system capability should be the driver for the decision.
- The process should be applicable to evaluate alternatives for supporting simulation components and enable the project manager to make informed decisions.
- The federation of these simulation systems should be supported utilizing the best middleware available for the task. This decision should be driven

by the functionality of the middleware and its necessity in the federation development process.

- The integration of systems and middleware should be supported to the maximal extent. The decisions of model integrators should be reduced to a minimum. This avoids ambiguity of interpretations. Existing solutions should be reused as much as possible.

3.1 Identifying Essential Tasks

In evaluations, operations and training, time and resources are always limited. It is necessary to concentrate the efforts on the essential tasks. For military operations, the METL introduced in section 2.1 is a way to support the decision makers in making the appropriate selection.

If, for example, the effect of a new type of body armor has to be evaluated, all tasks in the METL dealing with survivability need to be evaluated. Also those tasks for which the body armor may become a challenge, such as dismounted mobility, should be evaluated.

The result is a list of tasks in which the systems under evaluation plays significant roles. This list is represented in form of use cases that identify the action performer, the action target, and the action itself. This use case list can be supported by storyboards and organizational diagrams of the actors. These elements of the CIM are represented using UML. This CIM is the result of the first phase.

3.2 Setting the Tasks into Context: Building Scenarios, Vignettes, and Metrics

In the second phase, the actions of the use cases are combined to vignettes and scenarios. This allows definition of metrics for each of the tasks in the context of the operational environment.

This phase is a technical refinement of the CIM into more computer or simulation oriented views. The results are object and type hierarchies, action lists, sequences diagrams, and other artifacts of UML that describe a PIM. Figure 1 shows an example of an activity diagram describing a vignette of infantry engagements in an urban environment.

The resulting hierarchies are captured in UML, but they have been proven to support the communication with military experts as well. All tasks can now be described with metrics. Accuracy and resolution are decided based on military expertise, not on technical constraints.

The result of this phase is a description of the scenarios or vignettes that should be used to evaluate the aspects of the system under test. An easy book-keeping check can make sure that all use-cases of phase 1 are considered in at least one vignette in the PIM. Also, each role must be mapped to an object. If a complete MDA approach is used for the support, all objects are converted into elements of the common warehouse meta-model (CWM), described by the Meta Object Facilities (MOF). This possibility, however, was not applied in the underlying project so far.

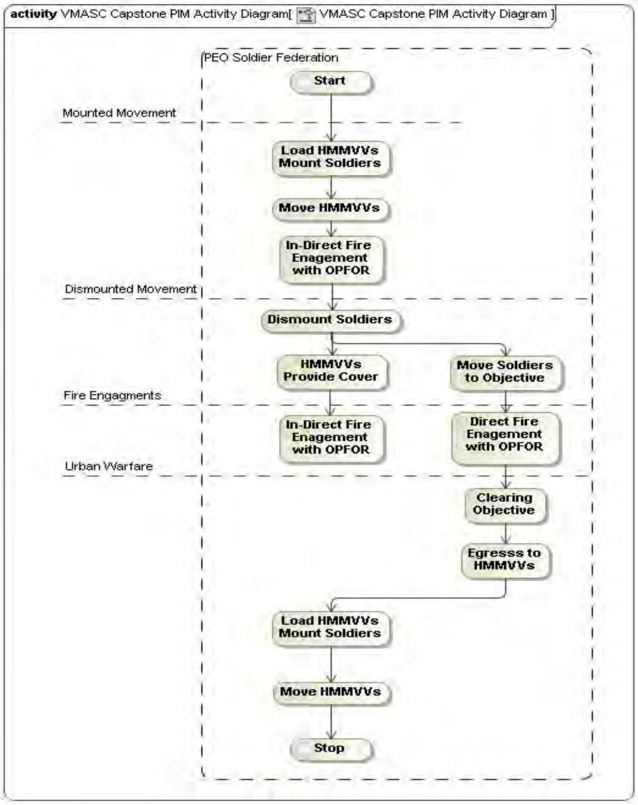
activity VMASC Capstone PIM Activity Diagram[VMASC Capstone PIM Activity Diagram]
PEO Soldier Federation
Start
Mounted Movement
Load HMMVVs Mount Soldiers
Move HMMVVs
In-Direct Fire Enagement with OPFOR
Dismounted Movement
Dismount Soldiers
HMMVVs Provide Cover
Move Soldiers to Objective
Fire Engagments
In-Direct Fire Enagement with OPFOR
Direct Fire Enagement with OPFOR
Urban Warfare
Clearing Objective
Egresss to HMMVVs
Load HMMVVs Mount Soldiers
Move HMMVVs
Stop

Figure 1: Activity Diagram

3.3 Identifying applicable Simulation Services

As implied by the methods and processes introduced in section 2.2, so far only operational requirements were used to define what should be used to evaluate a system. In the third phase, the simulated systems and capabilities are used to identify applicable simulation systems.

The requirement is that models must present their abilities in form of a PIM. The PIM defines a model's ability to model systems, capabilities, and activities. Concepts, properties, and processes need to be made transparent. The advantage of using UML artifacts is that it is possible to make the system transparent while protecting the intellectual property of technical details behind the implementation.

These PIMs look very similar to the artifacts produced in the last phase. Standardization across the armed forces will support alignment. In particular, organizations should name the same objects and processes identically and consistently, using these definitions to tag data describing the represented concepts, properties, and processes. Standards like the Military Scenario Definition Language (MSDL) and the Coalition Battle Management Language (C-BML) support potential solutions to this challenge. A common data administration of M&S and command and control would be helpful as well.

In any case, the PIMs of the simulation systems can be used to find out which elements of the PIM of the scenario and the vignettes can be represented or simulated and for which accuracy and resolution support the metrics identified by the military expert. The systems engineering process supports several objectives:

- Minimize the number of supporting simulation systems that represent the scenario
- Minimize the costs of obtaining the simulation systems and supporting data
- Maximize the use of simulation system under governance of the project manager
- Maximize the acceptance of systems, etc.

3.4 Preparing the Federation

The result of the last phase can most easily be visualized as a "colored" PIM. Each object and each activity is tagged with the simulation system information that can be used to represent it. Some objects and activities represent general concepts, such as soldiers and tanks, and they are likely to be found in many systems. Other features are very special, such as waveforms for special communications, and only a few simulation systems will provide them.

The colored PIM can now be used to support the decisions on which system should represent which objects and activities. This decision is triggered by the objectives enumerated at the end of the last subsection. The optimum for the analysis would be to maximize the coverage of operational requirements, but other constraints – such as time, funding available, or security concerns of model providers – can limit the feasible solution. However, no matter what motivates the ultimate selection of models, it is very likely that at least two models are selected that need to be federated to provide all necessary capability. Only in rare cases, everything is provided by one model, and no federation support is needed. Whenever and activity connects two objects hosted in different systems, or whenever properties needed to support the activities or the identified metrics for one object are provided by different systems, a federation is needed to handle the interactions and updates.

The patterns supported by MDA to move from PIM to PSM support integration with applicable middleware. Without limiting the general applicability, Figure 2 shows an update of attributes as supported by IEEE1516.3 as an example. Whenever an attribute needs to be updated, this sequence of calls to the RTI and resulting callbacks need to be programmed.

Whenever an attribute of an object is owned by another simulation system in the colored PIM, the sequence shown in Figure 2 will be generated. The placeholders in the pattern are replaced by the representing objects and simulation systems. When being mapped to a HLA federation, the attribute used in the Federation Object Model needs to be identified as well.

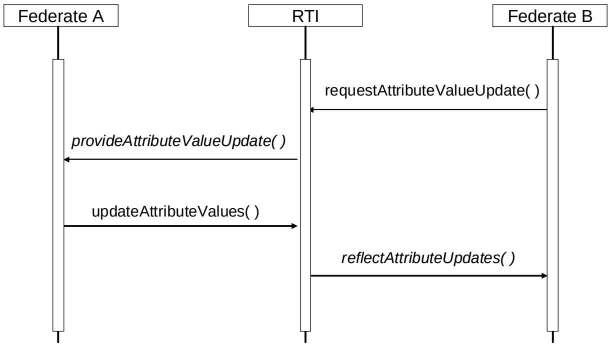
Federate A
RTI
Federate B
requestAttributeValueUpdate( )
provideAttributeValueUpdate( )
updateAttributeValues( )
reflectAttributeUpdates( )

Figure 2: Updating Attributes

In the same way, alternative middleware solutions can be supported, such as mapping to PDU of the IEEE1278 DIS, or objects and related methods within the object model used by the Test- and Training Enabling Architecture (TENA). The use of web services is another option. Furthermore, mixed strategies can be supported, such as using the Extensive Markup Language (XML) file based MSDL for initialization, the HLA based update of attributes and sending of interactions for simulation based information exchange during runtime, and web service based information exchange with C2 systems based on C-BML.

Another more conservative application is the definition of stubs for information exchange requirements to be enhanced by the implementing simulation systems. If a future simulation shall replace one of the current systems, the interface does not change. In fact, the initial simulation can test the federation and perform preliminary analysis. When the replacement simulation is implemented, it federates using the same interfaces. The MDA pattern identifies exactly what elements and procedures, methods, and callbacks need to be supported.

4 AN APPLICATION EXAMPLE

As mentioned in the introduction to this paper, the systems engineering process was designed while supporting PEO Soldier. PEO Soldier wishes to use simulation models to support the procurement process. Because no one model can currently support PEO Soldier's procurement tasks, they are undertaking an integrated approach, extending and federating existing models.

In the example task supported by the project team, the task was to evaluate different infantry soldier architectures in urban environments.

1. PEO Soldier decided that the following essential tasks will be sufficient for a first evaluation: transport in a HMMVV, direct fire engagement with insurgents on the top of a roof, clearing a house in search of at least one enemy inside, indirect and direct fire from hostile forces that will result in a call for fire to a supporting mortar unit.
2. The resulting scenario activities are captured in Figure 1. The objects were the roles of the use cases. The resulting PIM could be used to identify two models that if used in conjunction provide the desired capability and metrics for PEO Soldier: *One Semi-Automated Forces* (OneSAF) and *Infantry Warrior Simulation* (IWARS). While OneSAF provides the frame for the scenario, IWARS provides the high-resolution models to evaluate the effects of soldier equipment such as body armor and night vision goggles.
3. The scenario activities were separated into OneSAF activities and IWARS activities. Wherever a crossover shows up, information needs to be exchanged. Figure 3 shows the activities side by side. Figure 4 shows the derived view for indirect fire between OneSAF and IWARS entities minus RTI interface.

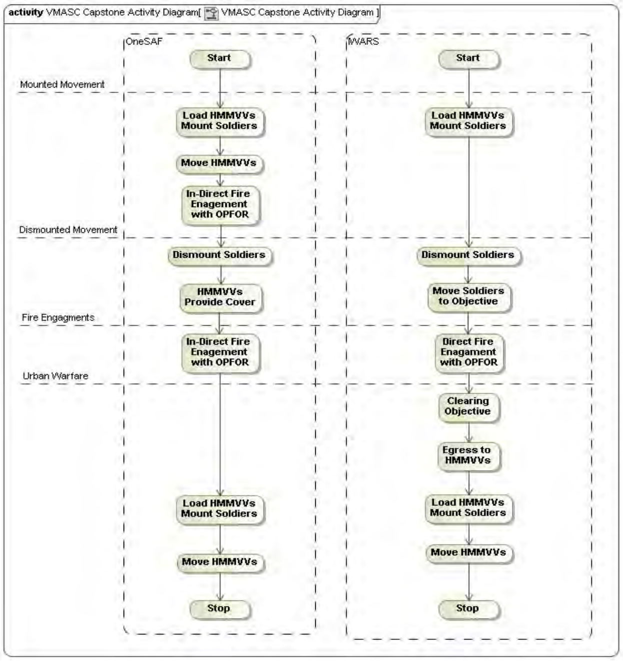
activity VMASC Capstone Activity Diagram[VMASC Capstone Activity Diagram]
OneSAF
IWARS
Mounted Movement
Dismounted Movement
Fire Engagments
Urban Warfare
Start
Load HMMVVs Mount Soldiers
Move HMMVVs
In-Direct Fire Enagement with OPFOR
Dismount Soldiers
HMMVVs Provide Cover
In-Direct Fire Enagement with OPFOR
Load HMMVVs Mount Soldiers
Move HMMVVs
Stop
Start
Load HMMVVs Mount Soldiers
Dismount Soldiers
Move Soldiers to Objective
Direct Fire Enagament with OPFOR
Clearing Objective
Egress to HMMVVs
Load HMMVVs Mount Soldiers
Move HMMVVs
Stop

Figure 3: Activities in OneSAF and IWARS

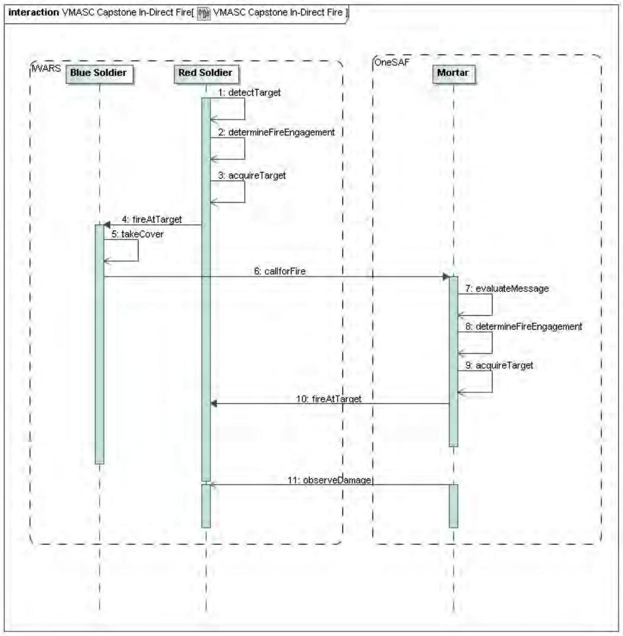

Figure 4: Indirect Fire Sequence

4. PEO Soldier decided to base the on-line coupling of OneSAF and IWARS on HLA as the interoperability standard. They used a federation object model (FOM) developed as part of the Modeling Architecture for Research, Experimentation, and Technology (MATREX) program as the information exchange model. Therefore, the information exchange requirements resulting from the PIM mapping in step 3 had to be mapped to RTI calls and the use of classes and interactions with attributes and parameters defined in the FOM. For example, the "call-for-fire" activity had to be mapped to a "call for fire" interaction as defined in the MATREX FOM.

The result in the project was twofold:

- The way the two simulation systems work together and orchestrate their activities is now captured in standardized form.
- The artifacts can be used to generate software stubs to allow the easy migration to alternative solutions (including auto-generating code with tools).

Even if only used for documentation, the systems engineering process supports a better understanding. Within the project, we observed many discussions regarding which simulation specific attributes to map to and from the FOM elements. Just having the common representation of objects and activities and sequences facilitates the discussion.

5 A COMMON APPROACH FOR ACQUISITION, DEVELOPMENT, TESTING, TRAINING, AND OPERATIONAL SUPPORT

Another aspect goes beyond the project that sponsored this work. ODU and VMASC are supporting a variety of organizations working in the domains of acquisition, development, testing, training, and operational support. All of these organizations use M&S in one way or the other to support measuring effects and capabilities. However, there is no sufficient framework established to ensure the alignment of assumptions and constraints. The PIMs as used in this paper can be a significant management help. The example of the metrics shall demonstrate the potential. As described in sections 2.1 and 3.2, metrics are defined in the context of four elements – mission, system, evaluation, and data – as shown in Figure 5:

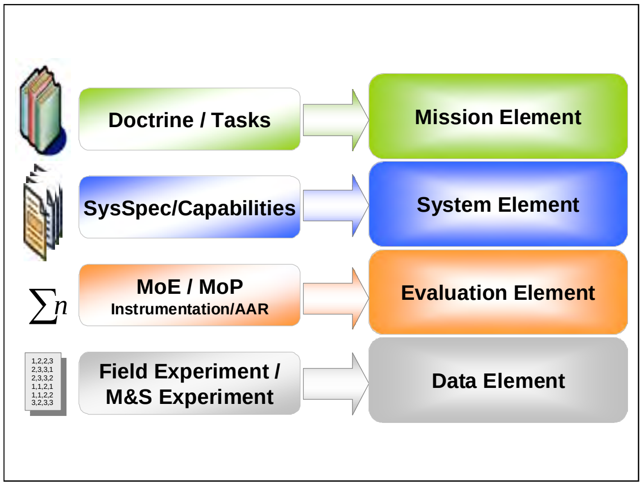

Figure 5: Metrics

- The mission and means framework sets the operational context for the mission essential task that is measured by a metrics. This defines what and why something has to be accomplished.
- The system to be evaluated (or the system under test) is the system and its capability currently delivering the functionality needed to conduct the mission essential task. This defines who is doing the task, and also how.
- The formula used to compute a value for the metrics is an element on its own.
- Finally, the collected data belong to the metrics context as well.

This form of metrics was first recommended by Jack Sheehan and Dr Paul Dietz for the US Army Test and Evaluation activities. The idea is not limited to testing but applicable in all domains. For example, it would make no sense if metrics used in the operational testing of systems are different from those used to decide which system to procure. Furthermore, if a new metric is successfully used in real world operations, it should be used for future procurements and testing as well.

The same is true for the PIMs derived from the METL, as well as for the PIMs describing scenarios and vignettes. It makes no sense to have different “business views” in different domains with respect to the same mission essential tasks.

6 SUMMARY

Using a systems engineering process, operational requirements and technical constraints can both be integrated into an MDA based framework supporting project managers, model developers, and evaluators in a consistent way. No information is lost in the translation process, so that managers and engineers can use the same framework to communicate their challenges and solutions without violating constraints and areas of responsibility of other team members.

The BOM standard (SISO 2006) is not fully supportive in all aspects of the MDA, but its application enables a significant portion of documenting M&S components and services as required for selection and orchestration.

The recommended solution enables project management of simulation based acquisition and supports the alignment of procurement, development, test, and training by introducing a common view derived from operational needs, including a set of consistent metrics.

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